Vulnerabilities Wrought by Economic Hardship

Gasoline Prices and Their Relationship to Rising Motorcycle Fatalities, 1990–2007

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Motor vehicle accidents are the leading cause of death among young adults. Although automobile fatalities have declined in recent years, motorcycle fatalities are rapidly increasing. The purpose of our research was to quantify the relationship between changing fuel prices and motorcycle fatalities.

Our findings suggest that people increasingly rely on motorcycles to reduce their fuel costs in response to rising gasoline prices. We estimate that use of motorcycles and scooters instead of 4-wheeled vehicles results in over 1500 additional motorcycle fatalities annually for each dollar increase in gas prices. Motorcycle safety should receive more attention as a leading public health issue. (*Am J Public Health.* 2009;99:1753–1758. doi:10.2105/AJPH.2009.159590)

MOTOR VEHICLE FATALITIES are a leading cause of death and a major public health problem in the United States, particularly among young adults. Forty-one percent of all injury-related fatalities in 2005 resulted from motor vehicle crashes among individuals aged 15 to 24 years.[1,2] However, rising gas prices have had a substantial impact in reshaping consumers' choices of transportation, and this has significant implications for motor vehicle fatalities. From 1998 to 2007, gasoline prices more than doubled in real terms, with much of the increase occurring from 2004 to 2007.[3] Whereas demand outstripped supply for hybrid gas-electric cars in the summer of 2008, automobile manufacturers continue to face difficulty in selling large, low-mile-per-gallon vehicles.[4] Other modes of transportation, such as public transportation, are becoming increasingly popular.[5,6] Research suggests that the decline in the number of miles driven in response to higher fuel prices has led to significant reductions in automobile fatality rates.[7]

Another consequence of the higher prices, however, has been increased demand for motorcycles and motored scooters, which use less fuel than cars and trucks. According to a recent survey, 26% of consumers considered substituting a motorcycle or scooter for a car in response to escalating fuel prices.[8] Motorcycle fatalities have risen substantially since the mid-1990s. We examine the extent to which rising gasoline prices explain increasing road fatalities from motorcycle crashes and call for greater attention to motorcycle safety.

The average fuel economy of new cars has never exceeded 30 miles per gallon in any model year.[4] For sport utility vehicles (SUVs), fuel economy ranged as low as 12 miles per gallon in 2008, and the most fuel-efficient standard truck for 2008 only managed 18 miles per gallon. By using electric motors to supplement power from a conventional gasoline engine, hybrid cars can achieve significantly higher fuel efficiency than equivalent gasoline-powered vehicles. The most fuel-efficient hybrid averages 48 miles per gallon in the city;[9] however, hybrids cost significantly more than conventional vehicles.[10,11]

By contrast, motorcycles and scooters are known for significant fuel savings because of their smaller engines. In 2006, according to the National Highway Traffic Safety Administration, the average motorcycle fuel economy was 56.1 miles per gallon.[12] A commuter choosing to ride a motorcycle instead of driving the average car would reduce his or her fuel costs by almost 50%, or by nearly two thirds compared with the average SUV.[4] Scooters commonly achieve higher levels of fuel efficiency than most motorcycles, with some as high as 100 miles per gallon.[13]

New motorcycles and scooters are also typically priced much lower than cars and trucks. Retail prices for the most fuel-efficient scooters and motorcycles available from major manufacturers range from $2000 to $4000. Approximately half of motorized scooter and motorcycle models from the 4 largest Japanese manufacturers retail for less than $10 000. Considering both their significant fuel savings and lower ownership costs, it is not surprising that sales of motorcycles and scooters have been booming.[13]

Motorcycles and scooters are more dangerous than 4-wheeled vehicles. An individual switching from a car to a motorcycle with no prior experience or training faces a high risk of injury or death. In fact,

over 90% of motorcycle riders involved in a crash do not have formal training, relying instead on family or friends or being self-taught.[14] A high level of riding skill is necessary because 2-wheeled vehicles are more dangerous than 4-wheeled vehicles in situations involving hazards such as road debris, rain, snow, and significant pavement imperfections. Furthermore, many popular motorcycles have higher performance in terms of acceleration and braking than most sports cars, requiring highly developed throttle and braking skills. Riding a motorcycle also leaves less room for mistakes arising from distraction or impairments such as alcohol consumption or fatigue. In fact, two thirds of motorcycle crashes are caused solely by motorcycle rider error.[14] Using the Fatality Accident Reporting System (FARS) database, which contains information on every vehicular fatality occurring on public roads in the United States, we examined the extent to which rising gasoline prices contributed to increasing numbers of motorcycle road fatalities.

METHODS

The FARS database is compiled by the National Center for Statistics and Analysis within the US National Highway Traffic Safety Administration. FARS is a census of all motor vehicle accidents on publicly accessible roadways in the United States in which at least 1 fatality occurs within 30 days of the crash. Fatalities may include both vehicle occupants and pedestrians. The database contains detailed personal, vehicle, and crash information on each accident, including demographic information for each fatality. For example, FARS provides information on the exact time of a crash, the location, the manner of collision, and other important individual, vehicle, and crash characteristics. Data are compiled from several sources, including police crash reports, emergency medical services reports, hospital medical records, coroner reports, death certificates, and state driver licensing and vehicle registration files. Additional information is available elsewhere.[15] A total of 755 479 individual fatalities occurred in the 18-year period from 1990 to 2007. Of these, vehicle body type was identified for 643 981 fatalities. We examined 56 168 motored cycle deaths, which included both drivers and any passengers the vehicle carried.

Street motorcycles—which exclude scooters, mopeds, off-road motorcycles, and their equivalents—account for 96% of all motored cycle fatalities. Unlike motorcycles, scooters and mopeds with small displacement engines require only an automobile license to operate in many states. Larger scooters, however, can be nearly as powerful and quick as many sport motorcycles; operators of both larger scooters and motorcycles are required to acquire the same sets of safe-riding skills and to undergo the same motorcycle licensing process. For our analysis, fatalities involving motorcycles, scooters, mopeds, and other motored cycles were combined and referred to simply as motorcycle fatalities.

Weekly gasoline retail prices are provided by the US Energy Information Administration (EIA), which is part of the Department of Energy. The EIA's Motor Gasoline Price Survey consists of nationwide telephone surveys of about 900 retail gasoline outlets every Monday. Retail gas prices include all taxes, and prices are provided for all grades. The EIA calculates mean gas prices using outlet sales, delivery volume, and population data. Gas prices are available for several cities and states as well as national averages. Additional information on survey methodology is provided elsewhere.[16] Information on numbers of registered motorcycles and other vehicles is provided by the Federal Highway Administration.[17]

Climate is an important factor influencing motorcycle demand. This analysis adjusts for climate using monthly average temperature and precipitation data. Temperature and precipitation data are provided by the National Climatic Data Center, which is part of the National Oceanic and Atmospheric Administration.

We examined total number of weekly motorcycle fatalities and weekly motorcycle fatalities per 100 000 people. We calculated fatality rates using yearly population estimates provided by the US Census Bureau. Independent variables included gasoline prices and climate variables. Because cycles use different grades of gasoline depending on make, we examined average retail prices for all gasoline grades. Diesel prices were excluded from the analysis because diesel engine motorcycles are rare and are not present in the FARS database. Mean monthly temperature in degrees and precipitation in inches were also included in the analysis. Climate is believed to be an important factor in both the decision to ride a motorcycle and the likelihood of crashing a motorcycle.

We condensed individual fatality data into a national sample of weekly fatalities and gasoline prices examined over a 907-week period. We used an autoregressive integrated moving average (ARIMA) regression specification to estimate what fatality numbers and fatality rates would have been assuming different gasoline prices, with adjustments for precipitation and temperature.

RESULTS

As illustrated in Figure 1, the correlation between real gasoline prices and the proportion of registered vehicles that are motorcycles is 0.89. Gasoline prices, adjusted to 2007 dollars, fell from $2.06 per gallon in 1990 to $1.36 in 1998. Over the same period, motorcycles as a proportion of all registered vehicles also declined, from 2.3% to 1.8%. From 1998 to 2006, when gas prices rose by 98%—to $2.70 per gallon in 2007 dollars—motorcycles as a proportion of all registered vehicles rose nearly 50%, from 1.8% in 1998 to 2.7% in 2006.

Figure 2 presents the total number of motorcycle fatalities occurring from 1990 to 2007 together with the real price of gasoline. In 1997, 2116 motorcycle riders died in road crashes. Motorcycle fatalities more than doubled over the following 10 years, reaching 5154 in 2007. In the late 1990s and early 2000s, universal helmet laws were repealed in 6 states

Note. Gasoline prices are adjusted to 2007 dollars.

FIGURE 1—Real gasoline prices and percentage of registered vehicles that are motorcycles: United States, 1990–2007.

(Arkansas, Florida, Kentucky, Louisiana, Pennsylvania, and Texas). Although the repeal of these laws has been blamed for the increasing motorcycle fatality rates in those states,[18] it does not explain the national trend in motorcycle fatalities: when these states were dropped from the sample, the trend shown in Figure 2 did not change much.

Table 1 provides the numbers of fatalities, fatality rates, and shares of total fatalities for motorcycles, passenger vehicles, and other vehicle types. From 1990 to 2007, fatalities in crashes involving passenger vehicles—including cars, trucks, SUVs, and vans—declined from 32 693 to 28 933, representing a drop in the fatality rate from 13.1 to 9.6 fatalities per 100 000 people. Over this same period, the percentage of road fatalities involving motorcycles increased from 8.7% to 14.5%, a rise of 67%. After declining from 1990 to 1998, the motorcycle fatality rate doubled from 1998 to 2007. Risk of having an accident may increase with engine power, and there has been a trend toward more powerful motorcycles in the United States. The percentage of motorcycle fatalities occurring on machines with engine displacements of at least 1 liter increased over 60%, rising from 27.5 in 1990 to 44.3% in 2007.

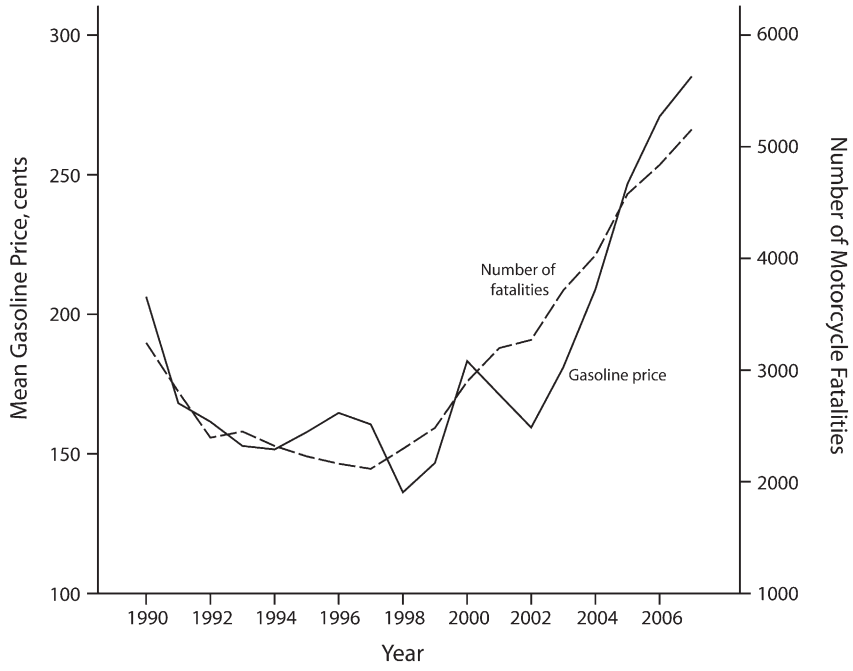
From 1990 to 2007, a total of 56 168 individuals were killed in motorcycle crashes. Table 2 provides the estimated number and rate of motorcycle fatalities (determined by ARIMA regression analysis) that would have occurred with different real gas prices. For example, we estimated that average annual fatalities would have been 1810, or 0.64 fatalities per 100 000 people, if gas prices had been $1 per gallon, but 4930, or 1.8 per 100 000 people, if gas prices had been $3 per gallon. For the period 1998 to 2007, if real gas prices had remained at the 1998 figure of $1.36, we estimated that total fatalities would have been approximately 23 712 compared with the actual total of 36 450, a 54% difference.

DISCUSSION

In response to escalating gas prices, increasing numbers of people have decided to use 2-wheeled transportation for their travel needs. Unfortunately, because motorcycles are significantly less safe than 4-wheeled vehicles (particularly for inexperienced riders), motorcycle fatalities have been increasing at the same time that passenger vehicle fatalities have declined.

Motorcycling has become increasingly popular because of higher fuel prices and the thrill and sense of freedom riders can enjoy. In addition, new motorcycles and scooters can cost as little as $2000 and have much higher fuel efficiency than hybrid automobiles, making them attractive to low-income individuals.

An increase in gas prices probably also leads to some substitution toward bicycling, walking, and alternative modes of transit, such as public transportation. However, motorcycle accidents are a more serious public health problem than accidents involving bicycling, walking, or public transportation, for a number of reasons. First, motorcycle riders are usually traveling at much greater speeds than pedestrians or bicyclists and the kinetic energy involved in motorcycle collisions is therefore substantially greater. Second, unlike pedestrians and, in some cities, bicyclists, motorcyclists do not travel on walkways that separate them from vehicular traffic, and the odds of collision with other, more massive vehicles are therefore higher. Third, because motorcycles are more feasible for commuting long distances, higher gas prices are expected to affect motorcycle use more than bicycle use or walking. Finally, fatalities on public transportation are



Note. Gasoline prices are adjusted to 2007 dollars.

FIGURE 2—Real gasoline prices and number of motorcycle fatalities: United States, 1990–2007.

rare. According to the American Public Transportation Association, there were 236 fatalities on public transportation systems in 2005, compared with 4576 motorcycle fatalities.[19] Increases in motorcycling in response to higher gas prices will result in greater numbers of fatalities relative to public transportation.

Only 20 states have universal helmet laws, and no state requires motorcycle safety gear beyond a helmet. Only Maine, Rhode Island, and, recently, Florida mandate rider education for all first-time licensees.[20] We speculate that many riders not using safety gear or declining to undertake additional formal training either do not appreciate the risks or discount them. The average motorcycle fatality also has a poorer driving history than the average automobile fatality. Furthermore, because motorcycle riders are less likely to possess a motorcycle license compared to automobile drivers, they are less likely to be tested on skills required to safely operate a motorcycle than are car drivers for skills needed to operate a car.

Houston and Richardson in 2007 calculated that elimination of helmet requirements in 6 states resulted in over 600 additional motorcycle fatalities.[18] Other research has demonstrated that universal helmet laws result in fewer fatalities.[21–24] We estimate that the increasing popularity of motorcycles because of higher fuel prices has resulted in nearly 13 000 additional road fatalities since 1998.

From the standpoint of fatality risk, motorcycling is a far from perfect substitute for driving a car in a number of important ways. First, a motorcycle rider does not have the benefit of riding within a protective steel cage; therefore, safety gear and training are important. Proper safety gear includes a Department of Transportation–approved helmet as well as a padded, abrasion-resistant jacket, pants, gloves, and boots. Unfortunately, safety gear may run into the hundreds or thousands of dollars and can represent a large fraction of the cost of most motorcycles. Gear can also be very uncomfortable in warm weather. Lack of gear and formal training substantially increases the risk of fatality. In fact, over 40% of motorcycle fatalities involve riders without helmets. The skills required to operate a motorcycle safely are very different from those required for 4-wheeled vehicles. For instance, a motorcycle tends to steer wherever the rider happens to be staring, so that by concentrating his or her attention on a given road hazard, the rider paradoxically increases the chances of colliding with that hazard.

Braking also is more complex than for automobiles because a motorcycle typically has independent front and rear braking. For example, whereas an appropriate response to a loss of traction on the front wheel is to momentarily release the front brake, the same response to a slipping rear wheel could result in a life-threatening crash. The range of potentially fatal road hazards is much larger than for automobiles, and the ability to identify and skillfully avoid road hazards, including other vehicles, is crucial. The number of potential hazards is greater in urban settings, and motorcycle fatalities are more likely to occur on urban, noninterstate roadways. This is why formal training can be so important in reducing accidents and fatalities.

Limitations

Lack of information on nonfatal injuries is one limitation of this study. We believe that fatalities and nonfatal injuries from motorcycle crashes are highly correlated and that our findings are therefore directly relevant to injuries. In fact, incapacitating motorcycle injuries increased to about 25 000 in 2006 from less than 15 000 in 1997.[25] A second limitation is that unobserved factors, including changing preferences for motorcycling instead of driving, may partially explain the trend in fatalities. Further research is

TABLE 1—Number, Rate per 100 000 People, and Share of Vehicle Fatalities, by Year and Type of Vehicle: United States, 1990–2007

		Fatalities								
		Motorcycles			Passenger Vehicles			Others		
Year	Price of Gasoline, $	No.	Share, %[a]	Rate	No.	Share, %[a]	Rate	No.	Share, %[a]	Rate
1990	2.06	3244	8.7	1.3	32 693	88.0	13.1	1196	3.2	0.5
1991	1.68	2806	8.1	1.1	30 776	88.9	12.2	1019	2.9	0.4
1992	1.61	2395	7.3	0.9	29 485	89.9	11.6	931	2.8	0.4
1993	1.53	2449	7.3	1.0	30 077	89.9	11.7	938	2.8	0.4
1994	1.51	2320	6.8	0.9	30 901	90.3	11.9	1007	2.9	0.4
1995	1.57	2227	6.3	0.8	31 991	90.8	12.2	997	2.8	0.4
1996	1.64	2161	6.1	0.8	32 437	91.1	12.2	991	2.8	0.4
1997	1.61	2116	5.9	0.8	32 448	91.0	12.1	1086	3.0	0.4
1998	1.36	2294	6.5	0.8	31 899	90.3	11.8	1115	3.2	0.4
1999	1.46	2483	6.9	0.9	32 127	89.8	11.8	1174	3.3	0.4
2000	1.83	2897	8.0	1.0	32 225	88.8	11.5	1181	3.3	0.4
2001	1.71	3197	8.8	1.1	32 043	88.1	11.2	1139	3.1	0.4
2002	1.59	3270	8.8	1.1	32 843	88.1	11.4	1162	3.1	0.4
2003	1.81	3714	10.0	1.3	32 271	86.7	11.1	1244	3.3	0.4
2004	2.08	4028	10.8	1.4	31 866	85.6	10.9	1320	3.5	0.5
2005	2.45	4576	12.2	1.5	31 549	84.2	10.7	1354	3.6	0.5
2006	2.70	4837	13.1	1.6	30 686	83.3	10.3	1331	3.6	0.4
2007	2.84	5154	14.5	1.7	28 933	81.6	9.6	1378	3.9	0.5

Note. Gasoline prices are in 2007 dollars. Passenger vehicles include 2-axle passenger cars, trucks, sport utility vehicles, and vans; other includes buses, semitrucks, and other multiaxle vehicles.
[a]As a percentage of all yearly vehicle fatalities.

TABLE 2—Actual and Estimated Number and Rate (per 100 000 People) of Annual Motorcycle Fatalities: United States, 1990–2007

	Mean Annual No. of Fatalities	Mean Annual Fatality Rate
Actual figure	3120	1.12
Estimated figure per hypothetical gas price		
$1.00	1810	0.64
$1.50	2590	0.92
$2.00	3370	1.20
$2.50	4150	1.47
$3.00	4930	1.75

Note. Estimated numbers were determined by autoregressive integrated moving average regression analysis. The average price of gasoline per gallon for 1990 through 2007 was $1.83 adjusted to 2007 dollars.

recommended to examine other factors, such as the relationship of peer effects, motorcycle advertising, or ownership costs, with motorcycle demand. Finally, a third limitation is that motorcycle fatalities occurring on nonpublic roads are not included in the data. We believe these fatalities to be positively correlated with public road motorcycle fatalities, and their omission should not substantially change the results.

Conclusions

Motorcycle safety deserves more public attention. Research has shown formal motorcycle training to be an important factor in mitigating the risk of motorcycle crashes.[14] However, only 3 states (Maine, Rhode Island, and, most recently, Florida) currently require successful completion of a motorcycle training course as part of their licensing requirements. Other states may provide riders an exemption to the state road test for motorcycles if they successfully complete training in approved courses. There does not seem to be a serious expectation of competent, safe motorcycling in the United States.

Improving motorcycle safety is an important public health imperative. Mandatory training is one approach to achieve this end, but so is subsidization of training programs. For example, subsidies could be targeted to lower-income riders, with training programs made available at community colleges. A review of international measures suggests that a system to constrain access to large motorcycles is yet another policy option. In New Zealand, for example, the engine size for newly licensed riders is limited for at least 6 months after they receive their learner license. The United Kingdom also limits engine size for beginners, and motorcycle training is compulsory. A restriction on engine size for learners recognizes the potential problem of people with little or no experience riding high-performance motorcycles. Higher-displacement motorcycles can be more dangerous, and there has been a trend toward these motorcycles in the United States. Graduated licensing programs restricting engine size for learners may significantly lower injury and mortality risk as riding experience is accumulated.

Motorcycling is becoming a more popular transportation

option in the United States, a trend partly explained by fuel price increases in recent years. However, motorcycle fatality rates have risen even as fatality rates from automobile crashes declined. Although more research is needed to better understand motorcycle fatalities and why they happen, policymakers should implement measures to increase formal training—especially for inexperienced riders—to encourage use of safety gear, and to constrain access to large motorcycles. It will save lives at relatively low cost. ■

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F.A. Wilson originated the study, led the writing of the article, and completed the analyses. J.P. Stimpson assisted with the study and analyses. P.E. Hilsenrath assisted with the writing and study design.

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No protocol approval was needed for this study.

References

1. American Public Health Association. At the intersection of public health and transportation: promoting healthy transportation policy. Available at: http://www.apha.org/NR/rdonlyres/43F10382-FB68-4112-8C75-49DCB10F8ECF/0/TransportationBrief.pdf. Accessed April 7, 2009.

2. National Center for Injury Prevention and Control. WISQARS leading causes of death reports, 1999–2005. Available at: http://webappa.cdc.gov/sasweb/ncipc/leadcaus10.html. Accessed April 7, 2009.

3. Energy Information Administration. Retail gasoline historical prices. Available at: http://www.eia.doe.gov/oil_gas/petroleum/data_publications/wrgp/mogas_history.html. Accessed April 7, 2009.

4. *Effects of Gasoline Prices on Driving Behavior and Vehicle Markets.* Washington, DC: Congressional Budget Office; January 2008.

5. Pucher J. Renaissance of public transport in the United States? *Transport.* 2002;56(1):33–49.

6. Bureau of Transportation Statistics. *Transportation Statistics Annual Report 2007.* Washington, DC: Dept of Transportation; 2007.

7. Grabowski DC, Morrisey MA. Gasoline prices and motor vehicle fatalities. *J Policy Anal Manage.* 2004;23(3):575–593.

8. Consumer Reports. Gas prices survey shows pain at the pump hurts at home. Available at: http://www.consumerreports.org/cro/cars/new-cars/resource-center/gas-prices-survey/overview/gas-prices-survey.htm. Accessed April 7, 2009.

9. Environmental Protection Agency. *2008 Fuel Economy Guide.* Washington, DC: US Dept of Energy; 2008.

10. Ohnsman A. Toyota Prius supply shrinks as waiting lists grow. Bloomberg. Available at: http://www.bloomberg.com/apps/news?pid=newsarchive&sid=ahXAyNA7my1E. Accessed April 7, 2009.

11. Leamy E. Hybrids fly off lot at record speed. ABC News, July 11, 2008. Available at: http://www.abcnews.go.com/WN/story?id=5358365&page=1. Accessed April 7, 2009.

12. Office of Highway Policy Information. Highway Statistics 2006. Available at: http://www.fhwa.dot.gov/policy/ohim/hs06/index.htm. Accessed April 7, 2009.

13. Welch J. Born to be . . . fuel efficient. *Wall Street Journal*, May 21, 2008. Available at: http://online.wsj.com/article/SB121131620487908103.html. Accessed April 7, 2009.

14. Hurt HH, Ouellet JV, Thom DR. *Motorcycle Accident Cause Factors and Identification of Countermeasures Technical Report.* Vol I. Washington, DC: Dept of Transportation; 1981.

15. National Highway Traffic Safety Administration. *FARS Analytic Reference Guide 1975–2007.* Washington, DC: Dept of Transportation; 2008.

16. Energy Information Administration. Weekly retail gasoline and diesel prices. Available at: http://tonto.eia.doe.gov/dnav/pet/pet_pri_gnd_dcus_nus_w.htm. Accessed April 7, 2009.

17. Federal Highway Administration. Policy information. Available at: http://www.fhwa.dot.gov/policy/ohpi/hss/hsspubs.cfm. Accessed April 7, 2009.

18. Houston DJ, Richardson LE. Motorcycle safety and the repeal of universal helmet laws. *Am J Public Health.* 2007;97(11):2063–2069.

19. *2008 Public Transportation Fact Book.* Washington, DC: American Public Transportation Association; 2008.

20. Governors Highway Safety Association. Survey of the states: motorcycle safety programs. Available at: http://www.ghsa.org/html/publications/survey/motorcycle/summary.pdf. Accessed April 7, 2009.

21. Houston DJ, Richardson LE. Motorcyclist fatality rates and mandatory helmet-use laws. *Accid Anal Prev.* 2008;40:200–208.

22. Morris CC. Generalized linear regression analysis of association of universal helmet laws with motorcyclist fatality rates. *Accid Anal Prev.* 2006;38:142–147.

23. Mertz KJ, Weiss HB. Changes in motorcycle-related head injury deaths, hospitalizations, and hospital charges following repeal of Pennsylvania's mandatory motorcycle helmet law. *Am J Public Health.* 2008;98(8):1464–1467.

24. Ulmer RG, Preusser DF. *Evaluation of the Repeal of Motorcycle Helmet Laws in Kentucky and Louisiana.* Washington, DC: Dept of Transportation; October 2003.

25. Hanna R, Austin R. *Lower-Extremity Injuries in Motorcycle Crashes.* Washington, DC: Dept of Transportation; 2008.